2000 CALFED Science Conference
Session Notes

Tidal Wetland Processes

Session Chair: Larry Brown
Session Notetaker: Michael Chotkowski

The prospect and pitfalls of breaching levees for tidal wetland restoration - Charles Simenstad, University of Washington.

Issue/problem:
-- This talk is essentially a review
-- 95% loss of tidal wetlands in SF bay in historic times, accompanied by reduction in once-abundant species (some wetland-dependent); loss of ecosystem “functions”

> -- What’s lost or diminished by diking wetlands: tidal prism, maintenance of marsh plain relative to sea level, nutrient cycling, habitat used by various species, support of food web inside and outside wetlands themselves (via export processes)

-- Diked/controlled marshes not a substitute, and may become pollution sources
-- Based on experiences elsewhere, breaching levees to restore tidal wetlands considered a useful strategy to recover lost ecosystem “functions”
-- Restoration of breached-levee wetlands isn’t a “slam-dunk”, may not produce desired end product, and takes substantial amounts of time

Approach:
-- Premises of breached-levee restoration:

> i. Ecosystem processes that created historical wetlands still persist
> ii. Redevelopment follows predictable trajectories that don’t produce “alternative ecosystem states”
> iii. Recovery timeframe is acceptable, and interim states are tolerable

Key findings:
-- Evidence of breached-levee restoration success, from ~25 studies elsewhere:

> i. some functions (e.g. floodwater storage and sediment accretion) rapidly improved)
> ii. tidal-wetland organisms quickly colonize new sites
> iii. initial stages often support large biomasses of fish and wildlife, esp. disturbance-loving animals
> iv. in cases of originally diked and controlled wetlands, predominance of exotic species declines after breaching

-- Some complications:

> i. subsidence of drained land may result in “elevation debt” that significant slows revegetation
> ii. reduced availability of sediment may limit accretion rate
> iii. initial post-breach states may be unsightly and cause water quality/public health problems (e.g. high biological oxygen demand problems; high trihalomethane concentrations)

iv. recruitment of native organisms may be slow or difficult; rapid colonization and high recruitment success of exotic species may reduce or prevent native species colonization

v. abundance of diked wetland-accommodated species may decline

-- Addressing of Complications:

i. Approach = wetlands designed and managed to deliver specific “functions and services”: poor record, unacceptable infrastructure and maintenance costs, detrimental side effects.

ii. Approach = supplementation of natural processes by enhancement without use of other control methods: few well-documented studies, even fewer experiments; tendency (of restoration planners) to want to skip over interim states that may be required to achieve desired end products.

iii. Approach = increased investment in engineering understanding of restoration processes: may help improve predictability of restoration

-- Dealing with Uncertainty in Restoration:

i. Conduct restoration as adaptive experiments, with ongoing monitoring and corrective action a possibility: timeframe may be unfeasible

ii. Use models of essential processes to test alternative scenarios: modeling state-of-the-art won’t support this

iii. Examine and document breached levee wetlands of various known ages in comparison to reference sites (approached used in BREACH study): need larger sample size and more geographical variation; unfortunately there are many confounding variables

iv. We think all three of the above should be employed in concert.

-- Brief introduction to the next three talks was given at this point...

Relevance:
Levee breaching is an approach likely to be adopted in the San Francisco Estuary by CALFED. Effects of island subsidence and caveats about outcome and time course of site evolution need to be kept in mind by planners.

Geomorphic evolution of freshwater tidal wetlands within breached levee sites of the Sacramento-San Joaquin Delta - Philip Williams, P. Williams & Associates

Issue/problem:

-- Need to understand physical processes underlying formation of tidal wetlands.

-- Can’t restore original delta, but would like to restore certain ecosystem features

-- Need to reestablish key processes to achieve this

-- Reminder: delta landscape arose by transgression of the ocean as sea level rose, not by accretion of sediment, as is the case in many other estuaries.

1. Sacramento River: high bed load, natural levees and distributory channels
2. San Joaquin River: lower bed load, many distributory channels
3. Whole system tidally dominated; result of all was highly dendritic original structure.

-- Diking of delta destroyed almost all of the natural tidal channels, especially the smaller channels.

-- No extensive areas of purely freshwater tidal marsh still exist in the delta anymore to act as guides to how these marshes should look. Only a few relict sites exist.

-- Diked agriculture lands became subsided, so when levees breached, result is deep water. E.g. Mildred Island.

-- Original processes differed from those that will by relied upon to restore subsided delta islands after breaching.

1. Sediment deposition rates seem much lower in deeply subsided sites than might be desirable for rapid.
2. Balance of depositional and erosive forces different in subsided islands.

Approach:
-- Analysis of Breach Study sites, including relict freshwater tidal marsh and flooded islands of various ages. Examination included elevation profile, apparent colonization rates of important plants,

Key findings:
-- Depth of tule edge increases with increasing age of flooded island sites, as rhizomes move out into deeper water.
-- Emergent vegetation becomes established very quickly, but edges don't move very fast thereafter (e.g., Donlon Island COE dredge mounds, Prospect Island West, Sherman Island)
-- Vegetated marshes in re-flooded islands were lower in elevation than reference sites

i. lower elevations are associated with a different kind of marsh than at the reference sites.

-- Depth of tidal channels is deeper in freshwater than in saltwater in SF Bay; it also increases with size of marsh drained; at least 10 ha required to get tidal channels with subtidal deepest depths.
-- Conceptual model elements:

i. Low subsidence areas colonize quickly after breaching --> endpoint is tule marsh with tidal channels after (e.g. at Mandeville Tip, after about 30 years)
ii. More deeply subsided areas do not colonize rapidly --> outcome uncertain. It's possible that they will silt in and become vegetated, but no flooded island examples in delta are known. It appears that some flooded islands (e.g. Frank's tract, age ca. 65 years) have changed very little over time and remain deepwater sites.

Relevance:
Described likely time course of revegetation in flooded island projects.

Contrasts in fish, benthic invertebrate, and insect assemblages at breached-leveed and reference wetlands in the Sacramento San Joaquin Delta - Lenny Grimaldo, DWR.

Issue/problem:
-- Addresses what happens to resident fish assemblages in flooded islands. Is there a relationship between flooded island age and resident fish assemblage? Are there different assemblages in flooded islands with different degrees of subsidence or differences in other major habitat features?
-- Background (some depends on previous two talks):

i. Degree of subsidence determines wetland type

-- Previous talks discussed colonization by emergent vegetation; it's also true that submergent vegetation (e.g. Brazilian waterweed, *Egeria densa*) also does not colonize deep water in heavily subsided flooded islands.
-- Fishes are well known often to be associated with specific habitat types.

ii. The San Francisco Estuary is highly modified and contains many introduced fish species

-- Roughly 98% of fishes collected during the study were exotic species.

iii. Recent invasion by Brazilian waterweed has been rapid and substantially changed nearshore habitat in invaded areas.

Approach:
Analysis of sampling conducted at breached island and reference sites in the delta. Variables studied and ANOVA methods used for hypothesis testing (parenthesis indicate categories used in hypothesis tests): mean fish density (among sites and species, among seasons, among Brazilian waterweed densities); mean insect density (among sites). Also used canonical correspondence analysis to investigate associations of fishes and roles of major physical variables. Examined gut contents of fishes (but results not detailed here).

Key findings:
-- There were no apparent relationships or trends between fish densities and wetland status or age
-- Physical attributes are better indicators of fish species likely to use a flooded island or reference area (than age of habitat). Most useful variables for distinguishing fish assemblages: water temperature and submerged aquatic vegetation density.
-- Native fishes were found in much smaller numbers than exotic fishes, and occurred in a variety of habitat types, depending on their ecologies. For example, chinook salmon were associated with open beach habitat.

Relevance:
Creation of a single habitat type will not benefit all native fishes. Speaker proposes that ecosystem "processes" should be looked at (as a means of creating a habitat mosaic that provides habitat and conditions suitable for various native fish species).

i. Creation of wetlands may only increase populations of introduced fish species, to the detriment of native fishes.

ii. Special attention should be given to value of restoring natural flow volume variability, which strongly influences distribution and probably numbers of native fish species. Ecological effects of flow variability cannot be replaced by increasing availability of permanently flooded tidal marsh.

Questions:
Q.: You used bar charts to argue that numbers of native fishes aren't different among sites of different age, but depth is a confounding factor, and it isn't clear that you couldn't explain the proportions (not absolute number) of native fishes with a combination of site age and depth. What say ye?
A: Reference site only had SAV. Other sites we could measure them in other habitats at flooded island sites. So, with species like prickly sculpin and tule perch that occur in SAV, naturally the reference site had higher numbers. Another thing: the time scale of the study is out of whack because we had no choice on the ages of the flooded islands. It may be that age of the island was important over the first, say, three years. We couldn't evaluate that, since we only had sites older than that.
Q.: Some previous talks indicated that native fishes seem to do better (than exotics) on flood plains, and you seem to be getting the opposite result in the delta. Could you comment on why that is?

A.: Main difference is that flood plain is temporary habitat, whereas the delta habitat is permanent. Seasonal variability will probably aid natives, and intertidal variability may also be important.

Breaching levees for tidal wetland restoration: what should we expect in the Delta? - Denise Reed, University of New Orleans.

Issue/problem: Breaching levees to create tidal wetlands is a strategy that may be employed by CALFED for restorative purposes. What should we expect?

Approach:
-- Structural attributes of breached-levee islands:
- i. open water depth
- ii. submerged aquatic vegetation (SAV)
- iii. tule marsh
- iv. channels and channel margins
- v. beaches/exposed intertidal

-- Delta gradients
- i. salinity/river flows
- ii. tidal range
- iii. turbidity/sediment supply
- iv. export pumps

-- Attributes and gradients play roles in determining local physical and ecological processes and so outcome of restoration efforts.

Key findings:
-- Reviews of conceptual model first presented by Phil Williams detailing fate of flooded island with minimal subsidence and flooded island with considerable subsidence
- i. shallow islands do build up peat because of the presence of tules, and should relatively rapidly evolve large tule beds with channels
- ii. major point about deep islands: estuary didn't originally evolve by deposition of large amounts of sediment, and sediment probably won't build up on bottoms of deep interiors.
- iii. intervention in case of deep islands possible; for instance, dredge spoils might be used to artificially restore shallow elevations.
- iv. suggestion given apparent mandate in R.O.D.: proceed with dirt movement to modify deep islands, within an adaptive management framework.
- v. Tradeoffs will have to be made in restoration – decisions will have to be made which choices should be made.
- vi. Uncertainties – there are many, especially about biological issues.

Relevance: Repeated and amplified Breach study conclusions about difference between shallow and deep flooded islands.

Geomorphological functioning - making the whole estuary work for CALFED - Jeremy Lowe, University of Newcastle.

Issue/problem:

-- Presentation of some experiences managing the Humber estuary (UK). Restoration goals in that system have most of same elements as those embraced by CALFED:

- -- nature conservation
- -- flood defense
- -- navigation
- -- water quality
- -- fisheries improvement

-- Humber estuary is a highly industrialized area with relatively little agriculture
-- Central issue in Humber example is need to make use of limited funds and restorable lands in such a way as to satisfy all users, and that restoration actions yield sustainable benefits (including low maintenance cost)

Approach:
-- Restoration of functional integrity of system as a geomorphological unit using restoration (= "realignment") parcels as tools

- -- Example: 1999 Humber "re-alignment" involved only ca.118 hectares of land
- -- approach must address problems and complications:
    - i. water velocity increases and erosion
    - ii. tidal asymmetry
    - iii. changing water levels
    - iv. modified habitat a sediment source or sink?
    - v. location/elevation combinations critical
    - vi. rising sea levels

Key findings:
-- Mean water level is affected by where in estuary a hypothetical 300 ha restoration parcel is located

- i. projects near estuary mouth have almost no effect on mean water level, whereas those in the inner part of estuary substantially reduce mean water level.
- ii. This effect may be tuned by adjusting elevations within restored parcel.

-- Dredging affects tidal flows

- i. trapezoidal estuary basically flood dominated, so sediment pushed into system
- ii. as sediment builds up, a dynamic equilibrium is achieved between flood and ebb dominance
- iii. dredging to create slot-like central channels may promote ebb dominance, causing loss of sediment to the sea

-- Sea level rise creates issues:

- i. may promote transport of sediment up the estuary ("roll-over")
- ii. Stress on flood embankments (=levees) increases
- iii. channels become increasingly constrained, increasing tidal amplitude and flood frequencies

-- Sea level rise problems may be mitigated by strategic location of restoration sites

- i. restoration of outer estuary for sacrificial area for sediment erosion (don't expect them to be sustainable)
- ii. restoration of inner estuary to act as sink for sediments and allow estuary to transgress (more sustainable)

-- Addition of sediment creates some risk that elevation rises will exacerbate tidal asymmetry and promote erosion
-- Human foolishness (esp. inappropriate siting of buildings) always a problem...
-- Parting shot: restoration site location and elevations are critical to success from geomorphological perspective

Relevance:
Design of tidal marsh restoration projects may need to take into account effects on hydrodynamics within estuary. Poor choices of location or elevation profile may lead to undesirable geomorphological changes locally or elsewhere.

Fish communities of San Francisco bay tidal marshes – Kathryn Hieb, DF&G

Issue/problem:
Tidal marshes are one of the most under-sampled habitats in the San Francisco Estuary, especially in the saltier water. Exceptions: UCD Suisun Marsh project, IEP Bay Study program. This talk reports a 1995-2000 IEP study that explored sampling methods and sampling of habitats in tidal marshes adjacent to northern San Pablo Bay. Also involved sampling of adjacent deeper water areas. Sampled fishes, caridean shrimps, brachyuran crabs.
Aims:

i. Test quantitative sampling of animals in tidal marsh habitats
ii. Sample marshes in several areas along a salinity gradient
iii. Sample adjacent deeper water areas.
iv. Compare results to other studies.

Approach:
-Tested quantitative sampling methods in tidal marsh habitats in habitat categories:

i. Marsh plain (1st- through 3rd-order channels)
ii. Larger 4th- and 5th-order channels
iii. Emergent vegetation
iv. shallow open water (full tidal and muted)

--Sampling methods work mostly done in and around Petaluma River and near its mouth in northern San Pablo Bay; some work done in northern Napa-Sonoma Marsh. Salinity range at study sites ranged from about 2.5 ppt to 25 ppt.

Key findings:
-- A lot of summarized relative abundance data presented.
-- Prevalent fishes in study areas included resident natives (including longjaw mudsucker, threespine stickleback, prickly sculpin) and resident exotics (including inland silverside, shimofuri goby, rainwater killifish, western mosquitofish); transients included exotic yellowfin goby and native Pacific staghorn sculpin and splittail.
-- Rank abundances of prevalent species (in cast net, throw cage, and lift net) presented. Species richness ranged from 8 to 14. Percent native species at Petaluma River and Napa Marsh sites ranged from 9% to 73%.
-- Risky to use data obtained in adjacent areas as a substitute for what might be found in tidal marshes. IEP Bay Study otter trawl and minnow seine data show quite different composition than tidal marsh data collected in this study. Differences may be due to gear biases alone or to actual differences. Seasonal variation may also play a role and must be considered.
-- Quantitative samples difficult to obtain, because different methods optimal in different habitats, high effort to get data, and variable gear efficiency under different conditions.
-- Could not actually compare densities between habitats because different gears used.

Relevance:

-- Getting good data for fishes in tidal marshes around the Bay will be difficult and will require careful planning. Sampling of deeper waters should not be used as a substitute for actual tidal marsh sampling if what is of interest is the tidal marshes.

Mutualistic interaction between Talorchestia traskiana and Salicornia virginica in a San Francisco Bay marsh - Steven Obrebski, SFSU Romberg Tiburon Center

Issue/problem:
-- Relates studies from 1996 – 1999 addressing question: is there an ecological interaction between amphipod *Talorchestia traskiana* and pickleweed (*Salicornia virginica*), and, if so, what and how strong is it? Pickleweed is the dominant halophyte in S.F. Bay marshes. Amphipods are very abundant: authors' estimate densities of 900 – 2200 m^{-2}, avg. about 1500.

Approach:
-- Field experiment in which densities of amphipod were manipulated in 1 m^2 enclosures; experiments done in Muzzi Marsh (Corte Madera: central bay) during pickleweed growth season. Early expectation was that because amphipods eat pickleweed, if amphipods enhanced then pickleweed should suffer.
-- Field observational study in which pickleweed growth rates were measured along with physical and biological environmental variables, including amphipod abundance.

Key findings:
-- Contrary to expectation, pickleweed growth rate and flowering rates were higher in presence of increased amphipod densities.
-- Amphipods burrow into soil or wrack during dry periods (long low tide exposures, etc.) to find higher humidities and lower temperatures than exist elsewhere. So, pickleweed provides them with physical protection.
-- A principal components analysis of the observational study data revealed that the first component, having high absolute coefficients associated with amphipod abundance, tidal heights, and distance from channels was a useful predictor of pickleweed growth rates. That variable, in conjunction with a second component consisting mainly of the March standing crop of pickleweed, accounted for 80% of the variation in the dataset.
-- A conceptual model stating a mutualistic relationship between pickleweed and *Talorchestia* was presented.

Relevance:
May help elucidate part of a trophic relay (or more simple mechanism) conveying resources from S.F. Bay tidal marshes into aquatic and terrestrial habitats adjacent to them, thus making clearer the role of tidal marshes in the larger ecosystem.

Questions:
Q.: Did you find the same abundances of *Talorchestia* and (unintelligible name of another bug) in *Spartina foliosa*?
A.: They occur there but they don't seem as abundant and the problem is it's a mucky substrate. We haven't had time to do much work there, but it's obviously a place where they (amphipods) can go when conditions aren't good.

Biodiversity in soil seed banks of restored and natural salt marshes of California - Gretchen Coffman, UC Los Angeles.

Issue/problem:
-- Salt marshes are productive and were historically a widespread ecosystem feature, but have generally been degraded by development and other forces.
-- Some restoration has been attempted in past 30 years.
-- Plants form an indispensable component of salt marsh biotas; so, evaluating whether plant assemblages are being restored at a site is important.
-- What are best means of evaluating "restoration performance" at restoration sites?
    -- Historically it's been evaluated solely by quantifying above-ground vegetation
    -- Author's thesis is that soil seed bank measures may be a useful complement to above-ground work.
-- Contradictory findings in literature with regard to wetland plant diversity as a function of restoration project age; however, few have used seed bank evidence, so question is open.

Approach:
-- Field investigations in southern CA and S.F. Bay in which soil seed bank diversity and abundances compared among salt marshes of different ages. Anticipated important variables: tidal elevation, distance along tidal creek, geographic locale.
-- Germination study in which samples incubated in field to see what germinates
-- Germination study in which seeds incubated in lab to see what germinates
-- Attempt made to predict "ecological functioning" or restoration "success" from seed bank measures

Key findings:
-- Tidal elevation, distance along tidal creek, geographic locale all affect densities of pickleweed (*Salicornia* spp.). Other species said to vary this way.
-- Native saltmarsh species diversity higher in S. California than N. California
-- Species richness from germination experiment seems to increase with time in both regions
-- Species diversity (which diversity measure was used was not stated) is also higher after a few years than at first, but older sites seem to be lower at oldest and reference sites
-- Species diversity "hotspot" at Pt. Mugu occurred between the high tidemark and the "wrack line."
-- Lab seed germination experiment yielded results similar to field germination experiment

Relevance:
Use of soil seed bank in vegetation studies at restoration sites seems to be a good idea.

Biophysical monitoring of wetland restoration and rehabilitation projects in San Pablo Bay - Giselle Downard, USGS.

Issue/problem:
-- Account of methods and current outcome of restoration of tidal marsh and associated habitats (three projects) along Hwy 37 corridor, mainly be reintroducing tidal flows

Approach:
Cullinan Ranch:

-- Purchased in 1992 by FWS for restoration; surveys of biological and environmental conditions conducted in 1994 and 1998 to establish record for comparison with future states.

Guadalcanal Village:

-- established as mitigation for development; detailed step-by-step plan with times, elevations, and specific success criteria

-- General points that were considered regarding success criteria for restoration:

i. Time frame of tidal marsh evolution
ii. Reference sites
iii. External variables (exotic species, disease, etc.)

Tolay Creek:

-- historically diked for agriculture; effect of diking was to greatly reduce tidal flows and degrading habitat. Restoration approach was to widen channel and remove obstacles to tidal flow. Substantial commitment to monitoring both for understanding processes and as an adaptive management tool.

-- success criteria:

i. target water levels reached at new upper pond
ii. transitional habitat for waterbirds created
iii. habitats of "sensitive species" increased and improved
iv. minimal required maintenance
v. mosquito production reduced from pre-project levels

-- use of GIS emphasized

Key findings:
Cullinan Ranch:

-- 1994: mostly disturbance-loving plant species, all exotic

-- 1998: more diverse assemblage of marsh-associated species, mostly native; cattails went from <1% in 1994 to >37% in 1998.

-- 1994: 25 bird species

-- 1998: 45 species, the most abundant representing complete turnover from 1994

Guadalcanal Village: no comments
Tolay Creek:

-- water levels immediately exceeded expectation after construction completed; immediate intervention was undertaken to limit flows to desired level.

-- success criterion nearly met for water levels; some transitional bird habitat has been created, and more is likely to evolve

Relevance:
Substantial change occurred at Cullinan Ranch and Tolay Creek soon after restoration work began. At Tolay Creek, a second intervention was necessary to achieve desired hydrodynamic regime. Author stressed need for careful monitoring and consideration of unique characteristics of each project.